How do individuals learn? What can teachers do to aid learning? Why do different teaching methods have different effects on individuals (or “why doesn’t everyone learn the same way I do?”). Complete answers to these and related questions are not known despite years of intensive research; however, what is known can be helpful to professors in understanding the learning and teaching processes. Chapters 13 through 15 explore these questions and suggest ways of incorporating them in engineering education. Chapter 14 examines two theories of cognitive development, Piaget’s and Perry’s, and offers implications for engineering education. Piaget’s theory leads to the learning theory known as constructivism, which is dealt with in Chapter 15, along with learning styles, Kolb’s learning cycle, how people learn, and, finally, motivation.

This chapter focuses on the natural differences among students that need to be considered in the planning of instruction and for handling interpersonal relationships. By accounting for such differences we can retain the students we have and also attract the nontraditional groups that are underrepresented in engineering. As Sections 13.3 through 13.5 show, the personality instrument discussed in this chapter, the Myers-Briggs Type Indicator (MBTI), has proven to be a successful tool in engineering education for recognizing and accommodating these differences.

The essence of the theory behind the MBTI is that “much seemingly random variation in behavior is actually quite orderly and consistent, being due to basic differences in the way individuals prefer to use their perception and judgment” (Myers and McCaulley, 1985, p. 1). “Perception” refers to the ways that we process information or become aware of the world around us. “Judgment” has to do with the ways we make decisions on the basis of what has been perceived. These ideas are based on the theories of the Swiss psychologist Carl Jung (1971) and their application and extension by Katherine Briggs and Isabel Briggs Myers. The MBTI has been used in education and industry as well as career and marriage counseling to help identify personality types in order to improve communication and open the possibilities for learning. Such knowledge is very important for professors and beneficial for students.
An indicator, not a test, the MBTI is a self-reporting instrument that offers a forced-choice format between equally valuable alternatives. In answering the questions or responding to certain word-pairs, we can discover our preferred way of dealing with, and living in, the world. Intrinsic preferences, though possibly inborn, aren’t always available to our conscious minds. The way we are raised and the situations we confront may force us to react in ways opposed to our inherent preferences. The MBTI allows us to arrive at a “reported” type and then examine the conclusion in light of our experiences, beliefs and feelings, all the time being free to accept or reject the result. The CCP (formerly known as Consulting Psychologists Press) claims “The *Myers-Briggs Type Indicator® (MBTI)* assessment is the best-known and most trusted personality assessment tool available today. As many as 1.5 million assessments are administered annually to individuals, including to employees of many Fortune 500 companies” CCP (2009). A collaborating statement from a more unbiased source but with reservations was reported by Lok (2012): “‘The Myers-Briggs assessment is probably the personality test most widely used by scientists and the general public,’ says John Lounsbury, a psychologist at the University of Tennessee in Knoxville who has conducted personality tests on Oak Ridge scientists. He and other academic psychologists say that Myers-Briggs is overly simplistic and misses out a few key traits, and that better tests exist. However, it remains popular because it is easy to understand, many people have been trained to administer it and there is a large body of interpretive books, websites and other materials that further boost awareness of the test.” Despite the concerns of psychologists, many people have found the MBTI to be useful for understanding and improving human interactions.

The MBTI does not merely classify people. Type does not refer to something that is fixed, permanent. Each type has its own ways of reacting to situations, but no one is true to type all the time. As McCaulley et al. (1983) point out, good type development often involves responding in ways that one does not spontaneously prefer. “The word *type* as used here refers to a dynamic system with interacting parts and forces. The characteristics and attitudes that result from the interactions of these forces do differ, but the basic components are the same in every human being” (p. 397).

13.1. SUMMARY AND OBJECTIVES

After reading this chapter you should be able meet the following objectives:

- Describe briefly the background of the Myers-Briggs Type Indicator and its development from the ideas of Carl Jung.
- Discuss the attitudes and functions of conscious thought and how the four preferences interrelate to form the matrix of sixteen personality types.
- Consider your own preferences in terms of the descriptions for each attitude and function, arriving at a rough estimate of your own type.
- Explain the importance of considering type differences among engineering students in the development of instructional materials, tests, and evaluations.

13.2. FROM JUNG TO THE MBTI

The seminal work on type theory was done by Carl Gustav Jung, the Swiss psychologist and contemporary of Sigmund Freud. His study *Psychological Types* was published in 1921 after
almost twenty years’ work in treating individuals and discussing problems and solutions with colleagues, as well as “from a critique of [his] own psychological peculiarity” (Jung, 1971, p. xi). Jung looks at the problem of type in the history of classical and medieval thought as well as in biography, poetry, philosophy, and psychopathology.

Katherine Cook Briggs was a lifelong student of the differences among individuals and how they relate to the way in which one functions in the world. In part her interest in personal differences grew out of her desire to be a writer and create fictional characters, and for this reason she was particularly interested in Jung’s treatment of biography in his book. Discovering Jung’s work in the English translation in 1923, Briggs is alleged to have said, “This is it” (Saunders, 1991, p. 59). Unfortunately, she was so impressed with Jung’s work and terminology that she burned her own notes and adopted the latter’s terminology. She shared this interest in personality with her daughter Isabel (later Isabel Briggs Myers) who continued studying type. Gifts Differing, by Myers and Myers (1980) gives an excellent discussion of their theory. With the onset of World War II, Myers desired “to do something that might help people understand each other and avoid destructive conflicts” (Lawrence and Sommer, 2009). She decided to find a way to put the theory to practical use and from this came the idea for a “type indicator.” She first developed an item pool that would reflect the feelings and attitudes of the differing personality types. Next, items were validated with friends and family followed by collecting data on 5000 high school students and 5000 medical students. After Consulting Psychologists Press https://www.cpp.com/products/mbti/index.aspx took over publication from Educational Testing Service in 1975, use of the instrument expanded greatly. It is also being used in England and Australia, and has been translated into more than 20 languages. According to McCaulley (1976), the fact “that similar career choices by the same types occur in disparate cultures suggests that Jung’s theory taps some fundamentally important human functions that cut across cultural teaching.” The third edition of the MBTI Manual was published in 1998 (Myers et al., 1998).

Nardi (2011) looks at hardwiring directly in his brain studies by using a 20-sensor EEG on 60 college students. He catalogs brain areas in relation to certain personality characteristics, noting how types correlate to usage levels of brain states, of how similar types use the same brain regions. For now, the extent of the study’s qualitative (as opposed to quantitative) results, though, keep it from being truly definitive.

13.3. PSYCHOLOGICAL TYPE

13.3.1. Attitudes and Functions

In Psychological Types, Jung postulated that everyone has a basic orientation to the world that indicates the directions in which energies or interests flow: to the outer world of people and events (extroversion, E) or to the inner world of ideas (introversion, I). He referred to this as an attitude toward the world. Either type, in the conscious aspects of life, processes information either through the senses (S) or by intuition (N) and makes decisions on the basis of this information either by logical, impersonal analysis (thinking, T), or on the basis of personal, subjective values (feeling, F). Jung regarded both thinking and feeling to be rational processes and so the term “feeling” here does not mean irrational. As to why there
are four functions (S, N, T, F), not more or less, Jung (1971, pp. 540–541) says he arrived at that number on purely empirical grounds. Through sensation we establish what is present, with its meaning determined through thinking. Feeling tells us its value, with possibilities delineated by intuition.

To these three Jungian pairs, Katherine Briggs added a fourth: a judging (J) or perceptive (P) orientation to the world. In her research she discovered that individuals tend to function primarily in either the perceiving or the judging mode. That is, some people (P) like to gather more and more information and adapt to situations as they arise; others (J) prefer more structure, and order, making lists, and trying to control events. The four dichotomies are shown in Table 13-1.

A person’s preferences are indicated by these dichotomies, but each person is free to use sensing or intuition, and, similarly, thinking or feeling. As with handwriting, anyone can write using either the left or the right hand; however, most have a preference for one over the other and tend to develop the skill in one more than in the other. The four dichotomies (EI, SN, TF, JP) can be arranged in a four by four table or matrix, giving sixteen personality types from interactions. Figure 13-1 in Section 13.4 gives an example of the matrix, with breakdowns of percentages for engineering disciplines. Then brief general characteristics of each type will be given (Myers and McCaulley, 1998; Quenk, 2009; Singer, 1972). McCaulley, Macdaid, and Kainz (1985) discuss ways of estimating type frequencies among the general population.

Orientation to Life: Extroversion (E) and Introversion (I). The first pair, extroversion and introversion, focuses on how one approaches the world. Ever since Jung first posited these descriptors of behavior, the terms have become part of the language and as used here they carry the standard psychological connotations. The outer-directed extrovert enjoys social contact, depends on interaction with others for personal satisfaction, and is energized by these interactions. The inward-looking introvert, on the other hand, tends to withdraw from such interactions, prefers quiet for concentration, and is energized by being alone. The easy communication of the extrovert is a problem for the introvert, who, preferring ideas, may

<table>
<thead>
<tr>
<th>Direction of energy or interests</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Outer world of people</td>
<td>Extroversion</td>
</tr>
<tr>
<td>Inner world of ideas and actions</td>
<td>Introversion</td>
</tr>
<tr>
<td>Preference of perception</td>
<td></td>
</tr>
<tr>
<td>Immediate and practical experience</td>
<td>Sensing</td>
</tr>
<tr>
<td>Possibilities and meanings of aspects of experiences</td>
<td>Intuition</td>
</tr>
<tr>
<td>Preferences for decision making</td>
<td></td>
</tr>
<tr>
<td>Logical, objective</td>
<td>Thinking</td>
</tr>
<tr>
<td>Subjective, personal, value-based</td>
<td>Feeling</td>
</tr>
<tr>
<td>Orientation to outside world</td>
<td></td>
</tr>
<tr>
<td>Ordered, planned</td>
<td>Judgment</td>
</tr>
<tr>
<td>Spontaneous, adaptive</td>
<td>Perception</td>
</tr>
</tbody>
</table>
have trouble communicating orally. In problem-solving, the extrovert tends to place greater weight on the situation and other people’s views, whereas the introvert tends to focus more on the conceptual framework of the problem (McCaulley, 1987). No one is purely extroverted or introverted, though some individuals clearly represent extremes of each type. Instead, the terms refer to preferred orientations. Anyone can exhibit both introverted and extroverted behavior. For example, an introverted teacher may approach a class with some fretfulness, mustering up all of his or her energy to begin the class, but once settled into the course, may feel comfortable and act the complete extrovert—within the confines of the class. Yet, the preferred orientation is that of an introvert. Each person carries the capability of developing both orientations but by preference tends to develop one of them. The same is true of the other three function pairs. This is an important point to remember while reading about the MBTI. Myers and McCaulley (1985, p. 5) caution that the Indicator is no substitute for good judgment and that the proper way to use it is as a stimulus to the user’s insight.

**Extrovert (E).** Roughly 50% of the general population (CAPT, 2014); about 33% of the engineering student population (McCaulley, 1990).
- Likes people.
- Likes action.
- Acts quickly.
- Communicates easily.
- Is applications-oriented.
- Feels energized by interaction with others.

**Introvert (I).** 47–55% of the general population; about 67% of the engineering student population.
- Prefers quiet for concentration.
- Likes ideas and concepts.
- Has trouble communicating.
- Relies on inner illumination.
- Prefers to work alone and is energized by doing so.

**Perception or Becoming Aware: Sensing (S) and Intuition (N).** Sensing (S) and intuition (N) characterize the perceptive function, or how one becomes aware of, or perceives, the world. The sensing person leans toward working with known facts rather than looking for possibilities and relationships as the intuitive person often prefers to do. He or she also tends toward step-by-step analysis and prefers to work by established methods. Intuitives favor inspiration and may work in bursts, quickly jumping to conclusions or solutions. Unlike sensing individuals, they are impatient with routine and may appear to be more imprecise. Using their imaginations, they see possibilities, whereas sensing individuals use their senses and work through the powers of observation. To a sensing type, soundness, common sense, and accuracy characterize real intelligence, which for an intuitive is shown by flashes of imagination and insight in grasping complexities. Attitudes characteristically developed from the preference for intuition include a reliance on sudden insight, an interest in the new, and a preference for learning through an intuitive grasp of meanings (McCaulley, 1978). This dichotomy was included in the Index of Learning Styles (see Section 15.2.3). A synopsis of the two types shows the following [general population results are from CAPT (2014) and engineering results from McCaulley et al. (1983) and McCaulley (1990)]:

Sensing (S). 66–74% of the general population; 53% of engineering student population.
- Uses senses and powers of observation.
- Works through step-by-step analysis.
- Likes precision.
- Prefers established methods.
- Is patient with routine.
- Works steadily.

Intuition (N). 26–34% of the general population; 47% of the engineering student population.
- Is imaginative, sees possibilities.
- Relies on inspiration.
- May be imprecise.
- Jumps to solutions (is quick).
- Works in bursts.
- Dislikes routine.

Decision Making: Thinking (T) and Feeling (F). Once all the data are in, whether by sensing or by intuition, one must then decide how to process the information and come to a decision. A person who prefers to be logical and analytical, weighing facts impersonally and objectively, shows a preference for thinking (T) as the mode of decision making; someone who bases decisions on subjective, personal values and standards uses feeling (F). Both poles are accessible to everyone, and often most individuals move freely between them; however, each person has a preferred mode.

Thinking (T). 40–50% in general population; 74% of engineering students: 77% male, 61% female.
- Is objectively analytical.
- Works through cause and effect.
- Tends to be logical.
- Tends to be tough-minded.
- Tends to be impartial.

Feeling (F). 33–45% male, 65–76% female in general population; 26% of engineering students: 23% male and 39% female. Clearly, male and female engineering students differ on this dimension.
- Understands people.
- Desires harmony.
- Stresses interpersonal skills.

Living in the World: Judgment (J) and Perception (P). The fourth preference pair identifies the way an individual functions in the world. This attitude is based on the person’s preference for the functions of perceiving and judging. An individual who prefers to use a perceiving function (S or N) to run his or her life tends toward being open to new perceptions, adapting to situations, and in general taking in information. This flexibility often leads to minimal planning and organization. For someone who uses a judging function (T or F) to conduct his or her outer life, the impetus is toward planning, organization, and closure. Thus, the JP preference indicates how an individual prefers to live in the outer world. If you are curious as to which of these applies to you, just think about the way you plan a vacation. Are you content as to fly somewhere and then to take it from there, making plans as you go (P)? Or are you appalled
by the thought of such a trip, preferring to schedule hotels, routes, stopovers, and so forth, well beforehand (J)? Do you find yourself taking in more and more information before finally writing that report—often at the eleventh hour (P)? Or do you plan it and work on it section by section, day by day (J)? As with all the pairs, both ways of living in the world are of course accessible to the individual. The dynamic interplay of all of the preferences (EI, SN, TF, JP) leads to sixteen combinations or types (see Figure 13-1).

**Judging (J).** 54–60% of the general population; 61% of engineering students.
- Prefers to live in a planned, orderly way.
- Likes to regulate and control events.

**Perceptive (P).** 40–46% of the general population; 39% of engineering students.
- Prefers to be flexible, spontaneous.
- Likes to understand and adapt to events.

### 13.3.2. Dominant and Auxiliary Processes

According to type theory, children are born with a predisposed preference for some functions over others (Myers and McCaulley, 1998). Lynch (1987) maintains that the dominant function is usually reflected by kindergarten age. In engineering terms, they are hardwired for a given type. This preference leads to fuller development of the preferred function and greater competence in it. A preference for sensing, for example, leads to the development of characteristics commonly seen in a practical-minded sensing individual. At the same time, the opposite pole of the preference tends to be ignored; in the above example a sensing child gives less priority to intuition and thus develops along quite different lines from another child who prefers intuition. It is apparent then that environment also plays a key role in one’s development, either reinforcing or demotivating development along certain lines. This “falsification” of type can lead one to develop a less preferred function but overall still not feel in control or confident in his or her abilities. In good type development each person uses all four processes, but one process becomes the leading or dominant.

In the literature about type, the roles of the dominant and the auxiliary are often compared to those of a general and an aide. In an extrovert, the general (dominant function) is at the forefront making decisions and taking the lead, for all the world to see. As a result, we say that for an extrovert, “What you see is what you get.” For an introvert, however, the aide (auxiliary function) stands as an intermediary with the outside world while the general makes plans inside a tent. The introvert, who focuses on the inner world, is difficult to know until one gets close enough to the individual. The dominant function remains hidden, which may be why introverts are often misunderstood.

To see how the dominant and auxiliary functions are determined, consider an INFP and an ENFP. For the ENFP, the fourth pair (that is, the choice between judgment and perception which indicates how the person lives in the world), here the P, indicates that this person prefers to conduct his or her outer life in the perceptive mode. So we only have to look back to the perceiving slot (the second letter, here N, intuition) to find the function used by this person in the outer world. If asked to characterize this individual’s type, another person would see the intuitive aspects. Now, by definition, extroverts show the world their strongest function; therefore, the N in this case is the dominant function. For the ENFP the dominant is extroverted...
intuition; the auxiliary is a balancing introverted feeling (F) (introverted because the theory postulates that the auxiliary always balances the dominant, which here is extroverted), with thinking as the third and sensing as the fourth or least developed. So for an ENFP:

Dominant: N (extroverted intuition—what world sees)
Auxiliary: F (introverted feeling)
Third: T (extraverted thinking)
Fourth: S (introverted sensing—least developed function)

For an INFP the P indicates the person extroverts his or her perceptive function. Thus a judging function is dominant since an introvert’s strength is within. The other perceptive function is third, and the fourth, or least developed, function, is judging (T). Thus,

Dominant: F (introverted feeling)
Auxiliary: N (extroverted intuition—what world sees)
Third: S (introverted sensing)
Fourth: T (extraverted thinking—least developed function)

These individuals trust introverted feeling the most and use it the most in directing their lives, with intuition in support of the thinking. To the world, they appear intuitive. Like most introverts they are easily misunderstood because their strength is inside, not as open to the world as the strength of an extrovert.

Note that this theory only works for people with fairly clearly developed preferences. If the score for one of the dichotomies is near neutral, the analysis can change significantly depending on which letter is used. For example, if an extrovert has the N-S score near neutral the dominant function can switch from N to S while the fourth function switches from S to N by changing the answers to one or two questions.

13.3.3. Good Type Development

Type development is seen as a lifelong process of increasing mastery or command over the functions of perception and judgment that one prefers, and corresponding but lesser development of the less interesting but essential processes. Myers and McCaulley summarize the process (1998):

- Development of excellence in the favorite, dominant process.
- Adequate but not equal development of the auxiliary for balance.
- Eventual admission of the least developed processes to conscious, purposeful use of these processes, even though this use may require the dominant and auxiliary to temporarily relinquish control in consciousness so that the third or fourth function can become more conscious.
- Use of each of the functions for the tasks for which they are best fitted.

13.4. APPLICATIONS OF THE MBTI IN ENGINEERING EDUCATION

The differences described by type theory are familiar parts of everyday life, and so the theory can be used for a wide range of applications: education, counseling, career guidance, situations involving teamwork issues, and communication. Any university counseling or psychological
center can provide the necessary testing services, or individuals can be certified through the training sessions such as those offered by the Association for Psychological Type (APT), the Center for Applications of Psychological Type (CAPT), or the Consulting Psychologists Press (see Section 13.7 for addresses). Thomas (1989) offers some preliminary results on “rapid MBTI self-classification.”

DiTiberio and Jensen (2008) extensively examine the relevance of the MBTI in teaching writing. Provost and Anchors (1987) discuss the uses of the MBTI in higher education. McCaulley et al. (1983) consider the results of the ASEE-MBTI Engineering Consortium of eight universities (see Figure 13-2). Their results are summarized later in this section. In the MBTI Manual Myers and McCaulley (1998) give numerous rankings of students and colleges by means of various preferences. Several authors discuss the MBTI and problem solving, with McCaulley (1987) offering a Jungian model. Yokomoto et al. (1987) discuss improvement of problem-solving performance and also consider student attitudes toward ethical dilemmas. Three ethical dilemmas were presented to students, who were required to make a decision on what further action, if any, might be taken to resolve them. Analysis of the results showed several biases arising from personality differences, with feeling types recommending action more strongly than thinking types in one situation. Campbell and Kain (1990) found that the most time-efficient types (N and J) were the least accurate. S and P types tended to be more accurate but took longer to achieve their accuracy.

13.4.1. Teaching Methods

Lawrence and Sommer (2009) synthesize learning style research involving the MBTI. The MBTI can be used to develop teaching methods to meet the needs of different types, especially on the sensing-intuition dichotomy, which has the largest effect on education. As McCaulley (1987) points out, S and N types approach problems from opposite directions: S moves from the specific to the general; N from the “grand design to the details.” She then makes a telling point: “In fields with relatively equal numbers of S and N students, such as engineering, the faculty have more of a challenge maintaining student interest than in fields, such as counseling, where students and faculty are more similar” (p. 47). Smith et al. (1973) found that personality traits influence student attitude and performance in self-paced instruction. They further note that a major weakness in college teaching appears to arise from the teacher’s and student’s lack of recognition of each other’s differences, which gives rise to the need for different learning activities. Self-paced instruction (Section 7.7), according to the authors, can be made more effective if instructional modules or packages are designed which fit different styles of student perception and judgment. Provost et al. (1987) studied a sample of professor of the year finalists to see how outstanding teachers use their type preferences. This limited study shows that type affects teaching style, assumptions one might make about teaching, and attitudes about what aspects of teaching are seen as rewarding. Outstanding teachers are able to relate to other types and to appreciate the inherent diversity.

The sensing-intuition (SN) dichotomy is perhaps the most important one for an engineering educator, both from the standpoint of the instructor and from that of the students (especially as sensing relates to mastering a body of knowledge and the corresponding skills central to a field of practice). Intuition has to do with the ability to think complexly and con-
textually. The percentages of type in the general and university populations alone tell a significant tale. Sensing types predominate in the general population; intuitives, in a university environment. More college professors are intuitive types than sensing types, and they tend to write exams that more frequently fit their own type (Lynch, 1987). If memorization and recall are important, sensing and judging types will perform better; if hypothesizing and essay tests are required, intuitive students will have an advantage. Aptitude tests are also designed to measure knowledge in the domain of introverted intuitives (IN). The data show that introverts consistently score higher than extroverts on the SAT-Verbal. Intuitives also consistently score higher than sensing types. The sensing-intuition differences, according to Myers and McCaulley (1998), are greater than the extroversion-introversion differences. O’Brien et al. (1998) concluded that “One of the most interesting findings was that students exhibiting the Intuitive type had significantly higher grades in the course than students preferring the Sensing type.” The sensing-intuitive dichotomy is discussed further in Section 15.3.

In the classroom, the thinking-feeling (TF) preference appears to have less importance than the others, but it can be argued that a predominance of thinking types in a class could “freeze out” the few feeling types. Is it possible that feeling types self-select out of engineering because of the more impersonal emphasis of the predominant thinking types in engineering? One colleague has suggested that it might be easier to teach ethics if students were more interested in human motivations (feeling types), rather than being concerned with building the best device (ST) or developing the most elegant theory (NT). Finally, it is important to remember that type theory does not make judgments on intelligence: All types can succeed in any area, and all types are represented in every area. What is important is to work to make survival of every type easier for engineering students. Paying attention to type differences and taking them into account in teaching goes a long way toward promoting such success. The fact that certain types predominate in certain careers says more about a type’s attraction to the field than whether he or she will succeed in it. Once an individual has gotten past the educational barriers to a given field, being different from the prevailing type can be an advantage since he or she will see things that others miss. Felder et al. (2002) conclude that “the MBTI is a useful tool for helping engineering instructors and advisors to understand their students and to design instruction that can benefit students of all types.”

13.4.2. Motivation

The MBTI can also be used to help students if the instructor understands the ways that different types are motivated. An instructor can help students gain control over their own learning and thereby reach more students. Even something as simple as a phrasing can be important. For example, feeling types respond better to a question that is phrased “How do you feel about . . . ?” whereas the thinking type prefers “What do you think . . . ?” Also, the quickness of the N types may discourage an S type, and in a classroom the quicker student is often more praised and honored; the “slower” student quickly forms an impression that he or she is lacking what the “best” students have. We use quotation marks to indicate that intelligence is not the consideration here. In the long run, the “slower” but more thorough and accurate S may be more correct and/or successful. And if not demotivated by the instructor, such a student may be a valuable addition to the class.
13.4.3. Interpersonal Relationships

The MBTI can also be used to help teachers and administrators work together more constructively. Type data from one sample show that administrators tend to be heavily J types [86% in Lawrence’s (1984) sample]. As in other areas, such as personnel cases in industry, awareness of type differences can lead to a more harmonious working environment. On a personal level, knowledge of type can be very helpful in counseling (Provost and Anchors, 1987). Carey et al. (1985) use type theory to look at the relationship between communication style and roommate satisfaction. The differences between judging types and perceptive types can often lead to conflicts. What a perceptive sees as a strength in the desire to have complete information or knowledge before proceeding, a judging person often sees as procrastination. And what a judging type sees as decisive action, a perceptive may see as close-minded and precipitate behavior. Differences on the extroversion-introversion and thinking-feeling dichotomies can also lead to problems. From type theory, interpersonal competence is related to extroversion and feeling (Myers and McCaulley, 1998). The focus of extroverts is on people and the external world; that of feeling types is on the effects of their actions and decisions on themselves and others.

In engineering, a great deal of work is done in teams. Clearly, it’s important that the members work together harmoniously. A good preparation for this takes place during team projects in undergraduate laboratories and design courses (see Chapter 9). Accounting for type differences and making students aware of each other’s different strengths can go a long way toward easing the tension that arises when, say, a perceptive can’t put an end to a literature search which his or her judging partner needs for the next day’s oral report. Giving and receiving criticism in these situations can also depend on the individual’s preferred way of functioning. Whitman and Malzahn (2012) used the more detailed MBTI Step II test to help students learn to assume leadership in engineering teams when the students’ skills could contribute significantly to the team.

13.4.4. Student Retention

Retention and attrition are complex issues every college or university must face. Godleski (1987) considers use of the MBTI to increase retention of underachieving college students. His preliminary results showed that there was no difference in extroversion or introversion, but a significantly larger number of sensing over intuitive types and perceptive over judging types who were in academic difficulty. Provost (1991) found type patterns among freshmen experiencing first-year difficulties, with analyses showing overrepresentation of TP combinations. Schurr and Ruble (1988) found that high school performance and the judging preference (J) were the best predictors of college performance. This report was a follow-up to their 1986 study which followed an entire entering college class. McCaulley (1976) describes a study at the Fenn College of Engineering at Cleveland State University comparing first year students who wanted to become engineers and seniors who successfully completed the program. The types in the four corners (the TJ or logical, decisive types) of Figure 13-1 increased their percentage from 45% as freshmen to 55% as seniors. The group showing the greatest loss, from 17.3% as freshmen to 9.2% as seniors, was intuitive-feeling (NF, a pattern more frequently found in the behavioral sciences and communication). McCaulley offers some reasons for these patterns (p. 397):
1. People learn in different ways. If the faculty teaches one way, they will favor some types over others.

2. Faculty members serve as role models for students, but they may not be appropriate models of engineers in industry. Students probably do not realize this.

3. Choice of textbooks and computer-aided learning can favor the learning pattern of some types and cause difficulties for others.

Yokomoto and Ware (1999), who summarized MBTI research in engineering, stated that retention in engineering was highest for students who prefer introversion, thinking and judgment. A more recent study at the University of Tennessee-Knoxville found that SJ types were significantly more likely than SF, NJ, and NF types to graduate in engineering (Parsons et al., 2008). They also found that NF types were significantly less likely to graduate in engineering than SJ, SF, and NJ types. Results from an electricity and magnetism course at Georgia Tech showed that ISFPs specifically and FPs somewhat more generally were most likely to fail the course (Thomas et al., 2000).

Kalsbeek (1987) offers a conceptual model for understanding student attrition. His comment offers an appropriate close to this section: By relating type data to student attrition, educators can consider how different types of students interact with different academic environments and thereby appropriately redesign the curriculum to include teaching styles that will accommodate diverse learning styles (see Chapter 15).

### 13.4.5. Distributions of Types in Engineering

As Figure 13-1 indicates, all sixteen types are represented in all areas of engineering; however, even the quickest glance reveals that certain types self-select into and are retained very markedly in engineering (McCaulley et al., 1983). For example, the corners of the table are strongly over-represented—what has come to be called the “tough-minded” TJ types. The feeling types (the two inner columns in the type table) are underrepresented with the lowest participation by ENFJ, ESFP, ISFP and INFJ types (In determining this order we took into account that more than 80% of engineering students were male and less than 20 % were female in 1990). McCaulley (1990) raises the question “Are engineering schools preparing their students adequately for the ‘people complexities’ of the profession?” That feeling types are in such a minority may indicate that the answer is no. Extroverts are also a minority, but the disparity is not as great. These groups tend to drop or transfer out of engineering. Since a great part of engineering work depends on communication and teamwork, it is important that faculty stress the importance of these skills and even teach them specifically (which of course would be appreciated by the extroverted, feeling, and intuitive types).

One speculation worth exploring is whether underrepresented groups in engineering, such as minorities and women, tend to fall into type categories that are only slightly present in Figure 13-1. If it is true, as the data to date indicate, that women classify more as being F than T, this could be part of the reason that they view engineering as “cold” and “unfriendly” (Seymour and Hewitt, 1994). If the ranks of engineering are to be filled in the future, and, as noted in Chapter 1, clearly the standard pool of potential engineering candidates of the past is dwindling, it is these groups that educators will have to look to and encourage. See also Alig (1994) for women majoring in engineering.
Figure 13-1. Distribution of the 16 MBTI Types Among ASEE–MBTI Engineering Students (McCaulley, 1990)

<table>
<thead>
<tr>
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<th>ISFJ</th>
<th>INFJ</th>
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Note: Numbers preceding bar graphs represent the percentage of the sample falling in that type. For example, 17.39% of all male engineers were typed as ISTJ and 20.18% of all aerospace engineers (male and female) were typed as ISTJ.
Engineering students differ from other college students. Compared with a sample group of college freshmen, engineering students are more often introvert, thinking, and judging types (McCaulley et al., 1983). Thus, the E, F and P students are underrepresented. Only on the SN scale were they similar to their peers.

Engineering disciplines attract different types of students (McCaulley et al., 1983). The fields with the highest proportion of extroverts were industrial (56%), computer (55%), petroleum (51%) and mineral (51%). Introverts were more frequent in aerospace (61%), geological (60%) and electrical (59%) engineering. The fields with the highest proportion of the practical sensing types were civil (69%), industrial (61%), mechanical (61%), and mining (60%). Intuitives were frequent in geological (62%), aerospace (60%) and metallurgical (54%). As noted above, all fields had a majority of T types, with the highest proportions in aerospace (82%), electrical (80%), and mechanical (80%). The fields with the lowest proportion of T types were undecided students (68%), geological (69%), computer (69%) and general (70%) engineering.

All types survived to become sophomores, but atypical types had lower retention rates (McCaulley et al., 1983). Judging types were slightly, but significantly, more likely to be retained (entering students were 63% J, retained were 65% J, p < 0.01). The practical SJ types were 34% of entering students but were 40% of those remaining. Note that there were no differences in retention between male and female students.

Less typical engineering students, extroverts and feeling types, learn better if given frequent feedback and appreciation; unfortunately, the types who are attracted to the field are the least likely to give such feedback. So it is up to the faculty to teach and model such behavior, which in turn will encourage students to do the same in their own work. Type knowledge can also help in identifying behavioral patterns and needs that may be beneficial in advising students (McCaulley et al., 1983; Lynch, 1987).

13.5. DIFFICULTIES WITH PSYCHOLOGICAL TESTING

The MBTI is prone to the same kinds of problems that plague any psychological test:

1. A student may not understand a question because of phrasing or vocabulary. The MBTI requires at least eighth grade English language skills (the Murphy-Myers-Briggs Type Indicator is used for grades two through eight). International students occasionally have difficulties taking the MBTI in English.
2. The wrong box may accidentally be marked.
3. Students may mark what they feel they “ought” to think or may try to “psych-out” the tester. Unconscious biases may also affect the results.
4. Current environmental stress may change one’s answers temporarily.
5. Results may be misinterpreted. With the MBTI a little learning can be a dangerous thing, for it’s easy to turn into a parlor game and make it little more than a horoscope reading. Accurate interpretation is assured if a qualified tester is present such as a psychologist, a counselor, or someone certified to administer the MBTI. In particular, the distinct “types” or categories that people are classified in are problematic if any of the scores are near neutral. Scores near neutral should be listed as, for example, S/N or if N is slightly higher N/S. The analysis for dominant and auxiliary functions is unreliable if scores are close to neutral on J–P or I–E scales.
6. Reliability. The MBTI is reliable, but people can change. Times of stress may lead to differing results, and over a period of years growth may be reflected in a change in the reporting of a type preference. However, such changes are expected and predicted within type theory. For example, as one enters middle age, it’s common for compensatory development to occur in the less preferred functions (Myers and McCaulley, 1998). Seventy-five percent of people who have retaken the MBTI after one to six years have not changed or have done so in only one category. More information can be found in the reliability studies reported in Chapter 10 of the manual by Myers and McCaulley (1998).

7. Validity. The MBTI has good face validity. The results generally seem true to the test taker. There is also high face validity when one person types another person whom they know well (Carlson, 1989). Does the MBTI measure what it is trying to measure? This is a problem with all psychological tests: What they try to measure is usually based on a psychological theory. Thus, is the underlying theory valid? If it is, does the test accurately measure this? Chapter 11 in the manual discusses more than 100 studies relating to validity.

In addition to the problems common with all psychological tests, as noted earlier, the professional psychology community does not like the MBTI. They quote all the reasons above (with special emphasis on the use of distinct categories), they prefer other tests, plus they probably don’t trust the MBTI because the test has been used in many ways by people who are not professional psychologists.

13.6. MBTI MODEL FOR PROBLEM SOLVING

The goals in using the MBTI model of problem solving are to improve the problem solving skills of students and to help them gain respect for others whose minds work differently from their own. The following is a brief and simplified overview of Myers’ problem-solving model (Myers, 1991; McCaulley, 1987). The strategy is to use one process at a time and to use it in its own area. Don’t, for example, use sensing for seeking new possibilities or feeling to analyze an equipment problem.

1. **Use sensing (S)** to face the facts, to be realistic, to find what the situation is, to see your actions, and to see other people’s actions. Do not let wishful thinking or sentiment blind you to the realities.

2. **Use intuition (N)** to discover all the possibilities, to see how you might change the situation, to see how you might handle the situation differently, and to see how other people’s attitudes might change. Do not assume that you have been doing the only obviously right thing.

3. **Use thinking (T)** to make an impersonal analysis of the problem; to look at causes and their effects; to look at all the consequences, both pleasant and unpleasant; to count the full costs of possible solutions; and to examine misgivings you may have been suppressing because of your loyalties to others or because you don’t like to admit you may have been wrong.

4. **Use feeling (F)** to weigh how deeply you care about what your choice will gain or lose; to put more weight on permanent than on temporary effects, even if the
temporary effects are more attractive right now; to consider how other people will feel, even if you think they are unreasonable; and to weigh other people’s feelings and your own feelings in deciding which solution will work.

It is likely, and natural, that an individual will choose a solution that appeals to his or her favorite process, but such a solution will be more effective or successful if the facts, possibilities, consequences, and human values are considered. What can go wrong if any of these are ignored? Intuitives may base a decision on some possibility without discovering facts which may preclude the conclusion. Sensing types may settle for a faulty solution because they assume none better is possible. Thinking types may ignore human values. Feeling types may ignore consequences. Thus, what can make the process difficult is that the problem solver is asked to use strengths opposite to his or her own.

Using the attitudes:

1. **Use extroversion** (E) to see events in the environment that may influence the problem, to seek people who may have information about the problem, and to talk out loud about the problem as a way of clarifying the ideas.

2. **Use introversion** (I) to consider ideas that may have a bearing on the problem, to look for deeper truths that may be obscured by current fads, to think alone deeply about the problem.

3. **Use judgment** (J) to stay on track and not be diverted, to plan ahead, and to push yourself and others toward a solution.

4. **Use perception** (P) to ensure that you have looked at all aspects of the problem, to watch for new developments, and to avoid jumping to conclusions before all the facts are in.

Yokomoto and Ware (1999) summarized the results obtained on comparison of MBTI characteristics and student learning. The correlation between scores on problem solving exams and homework is higher for sensing students if the exam problems are very similar to the homework, and higher for intuitive students if the exam problems use the same conceptual framework but are different from the homework. Judging types did significantly better in a technical writing class than did perceptive types.

### 13.7. CONCLUSIONS

The Myers-Briggs Type Indicator offers engineering educators a workable instrument with which to meet the changing needs of engineering education. Measuring preferences as indicated by the students themselves, it is not meant to measure the strength of a trait, as other psychological instruments do. Consequently, it is fairly simple to implement and interpret without requiring a staff psychologist within an engineering department. Attention to differences also makes tremendous common sense as the diverse needs of a new population of students must be met before they can succeed in engineering. We can increase participation in the field as well as increase productivity. Quite possibly, as McCaulley (1990) points out, use of the indicator may help move students toward greater maturity of cognitive development in Perry’s model (see Chapter 14, and Felder and Brent (2004)). Finally, to stress that engineering educators must acknowledge that students learn differently, Staiger (1989) concludes: “It would help to have the phrase ‘equal opportunity for learning’ included in all university admission statements as a constant reminder” (p. 143).
13.8. CHAPTER COMMENTS

There is much to consider in the areas of student types, development, and learning theory. And all interact, thereby further complicating an already difficult equation. In such a complex area, each theory looks only at a small part. The Myers-Briggs Type Indicator offers a starting point for looking at the differences between and among students. More information on the MBTI can be obtained through the following organizations:

- Association for Psychological Type, 9140 Ward Parkway, Kansas City, MO 64114 (www.aptcentral.org)
- Center for Applications of Psychological Type, Inc., 2815 NW 13th St, Gainesville, FL 32609 (http://www.capt.org)
- CPP (formerly Consulting Psychologists Press), 3803 East Bayshore Road, P.O. Box 10096, Palo Alto, CA 94303 (https://www.cpp.com/en/index.aspx)

There are many additional sources available on the internet. We suggest the following:

- The Myers & Briggs Foundation can be accessed at http://www.myersbriggs.org/
- Interesting type descriptions and links can be found at http://www.typelogic.com/
- A free test based on Jung’s theories and MBTI is available at http://www.humanmetrics.com

HOMEWORK

1. Consider the process of selecting an adviser for graduate work.
   a. How close a match between student and adviser is necessary?
   b. Which are more important: EI, SN, TF, JP?
   c. How can you figure out the professor’s type?
2. Think back to your undergraduate courses. Recall a particular teacher who wasn’t fully effective because of a preference for one type over another in his or her approach to teaching. What could this person have done to improve his or her teaching?
3. Determine the dominant, auxiliary, third, and fourth functions for the following types:
   a. ESFJ
   b. ISFJ

REFERENCES


McCaulley, M. H. (1978). *Applications of the Myers-Briggs Type Indicator to medicine and other health professions*. Gainesville, FL: Center for Applications of Psychological Type.


